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ABSTRACT

This study uses survival analysis to investigate when maltreated children may become at risk in their school performance. While past research captures the average effect of maltreatment on academic achievement, it has not addressed how the effect is distributed across time. Using a sample of 330 maltreated and 330 non-maltreated children, researchers concentrated on poor grades (D, F, or Unsatisfactory) in English and mathematics and grade repetitions as their outcomes of interest. Maltreated children displayed greater risk than non-maltreated children for most outcomes from kindergarten through sixth grade. First grade was the time of highest risk for grade repetition for maltreated children whereas second grade was the period of highest risk for non-maltreated children. For mathematics and English grades, kindergarten was the time of greatest risk for both maltreated and non-maltreated children. While both groups exhibited similar outcomes for English grades, they varied for grade repetitions and math grades. While it is not surprising that maltreatment is associated with higher risk, these results suggest that maltreatment status may also produce differences in the timing of the risk. Included are 12 graphs which present the statistical findings. (RJM)

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The Timing of Academic Problems Among Maltreated and Non-Maltreated Children

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Presented at the 101st American Psychological Association Convention held in Toronto, Ontario on August 20-24, 1993

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ABSTRACT

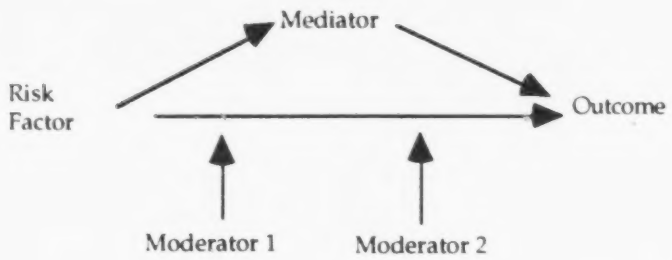
This study uses survival analysis to investigate the timing of risk of poor school performance for a sample of 330 maltreated and 330 non-maltreated children. The outcomes of interest were poor English and mathematics grades (D, F, or U (unsatisfactory)) and grade repetitions. Maltreated children displayed greater risk across kindergarten through the sixth grade than non-maltreated children for most outcomes. First grade was the time of highest risk for a grade repetition for maltreated children whereas second grade was the period of highest risk for non-maltreated children. For mathematics and English grades, kindergarten was the time of greatest risk for both maltreated and non-maltreated children. These results provide more information than traditional statistics. While it is not surprising that maltreatment is associated with higher risk, these results suggest that maltreatment status may also produce differences in the timing of the risk.

The Timing of Academic Problems Among Maltreated and Non-Maltreated Children

Models of Risk

Risk has become an increasingly important concept in developmental research, particularly that of developmental psychopathology. While risk factors have been identified for many developmental outcomes, there is still a great deal we do not know about the links between these factors and outcomes of interest. Most models, such as Figure 1, typically do not go beyond postulating a link between a risk factor and an outcome and including a few variables that moderate or mediate the relationship.

Figure 1: A model of the relationship between a risk factor and a developmental outcome.



Much of the past research has focused on the relative amount of risk created by these factors. For instance, does poverty or a major life event (such as the death of a parent) create more of a risk for behavioral problems. Moderators, such as gender, have been included in these models to account for group differences in the amount of risk. A common question is whether a factor places women at greater risk than men for a negative outcome. Likewise, mediators, such as the amount of parental conflict, have been included to distinguish the indirect and direct effects of risk factors on the outcome.

Maltreatment as a Risk Factor

In the past decade, many researchers have been exploring the risk associated with maltreatment and its' impact on developmental outcomes as diverse as attachment, peer

relations, academic achievement, depression and problem behaviors (Cicchetti & Carlson, 1989; Erickson, Egeland & Pianta, 1989; Eckenrode, Laird & Doris, 1993; Kendall-Tackett, Williams & Finkelhor, 1993). Many authors have argued for the importance of focusing on age-appropriate tasks as a means of gaining insight into the impact of high-risk environments on developmental psychopathology (Sroufe & Rutter, 1984; Cicchetti, 1989). During a child's elementary school years a major developmental task is cognitive and social adaptation to the school environment. Academic difficulties could be signaling a failure to adapt to the environment, particularly during the initial transition into academic life (Alexander & Entwisle, 1988). Maltreatment, socioeconomic status, and geographic and school mobility have all independently been found to have a detrimental impact on academic achievement at various points in the life course (Alexander & Entwisle, 1988; Broman, Bien & Shaughnessy, 1985; Cadigan, Entwisle, Alexander & Pallas, 1988; Eckenrode, Laird & Doris, 1993; Holmes & Matthews, 1984; Jackson, 1975; Safer, 1986; Wodarski, Kurtz, Gaudin, & Howing, 1990). However, there have been few studies that have examined the impact of maltreatment on academic outcomes such as grades and grade repetitions. Eckenrode et al. (1993) and Wodarski et al. (1990) found that maltreated children had lower grades and a higher incidence of grade repetitions than non-maltreated children.

Timing Components of Risk Factors

Specifying the relationship between maltreatment and academic achievement employing a model such as that shown in Figure 1 leaves several important questions about the link between maltreatment and these outcomes unanswered. Many of these questions have to do with time. A sample questions would be 'How does maltreatment influence the timing of academic difficulties?'. Willett & Singer (1989) distinguish between conceptualizations of time as an outcome and time as a predictor. Within each conceptualization, questions can be asked about the effects of time within and between individuals. Table 2 illustrates the categories of questions suggested above.

Table 2: Two Conceptualizations of Time: Sample Questions About Academic Achievement.

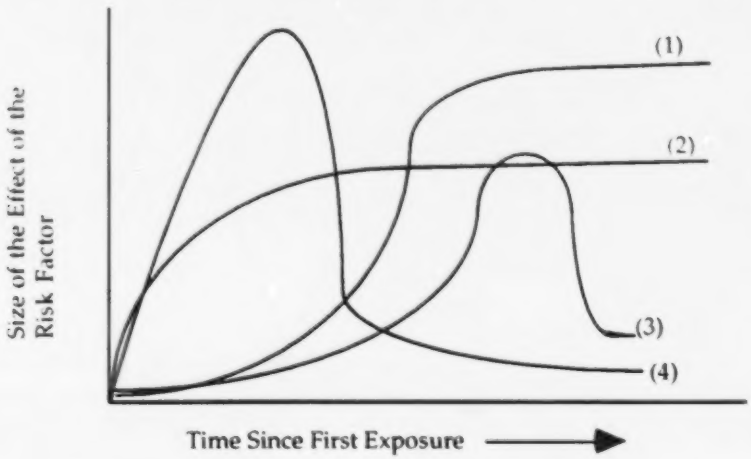
	Intraindividual Analyses	Interindividual Analyses
Time as Outcome	How long do children stay in school before repeating a grade?	How do child characteristics (such as maltreatment) influence the time before a grade repetition?
Time as Predictor	How do children's grades change over time?	How do child characteristics (such as maltreatment) influence grade changes?

In about the previously discussed model of risk, child characteristics correspond to moderators for both conceptualizations of time. To illustrate the difference between these conceptualizations, suppose that we had a child's entire academic record. If time were the outcome we would have to select a substantively meaningful event such as a D or F or U (unsatisfactory) in mathematics. The outcome would be the duration until the event occurred. Willett & Singer (1989) advocate using survival analysis when conceptualizing time as an outcome. However, if we were interested in how the child's grades were changing across time we could use a technique called growth modeling (Willett & Singer, 1989; Willett, Ayoub, & Robinson 1991). A function is fitted for each child's academic history. Thus if a child's performance improved during their career the function would be a positively sloped line. While conceptually the distinction between predictor and outcome is valid, mathematically and statistically, both predictors and outcomes are modeled as functions of time.

While past research captures the average effect of maltreatment on academic achievement, it does not address how the effect is distributed across time nor how the moderators influence this distribution. Figure 2 presents four hypothetical timing distributions, with the x-axis representing the time since initial exposure to maltreatment and the y-axis representing the size of the effect of maltreatment on an outcome. This model assumes continuous measurement of the outcome. In all the distributions, if the line stays above the x-axis the effect is still present. The distribution of the effects

corresponds to the distribution of risk in that if one examines homogeneous groups of children (in relation to current age, SES, race, gender, etc.) with age of onset equal to X, all of those children should have approximately the same type of distribution. While different age of onsets could correspond to different impacts on the outcome, it seems feasible that this would only result in variations in the size of the impact and not the typology of shapes illustrated in Figure 2.

Figure 2: Four potential distributions of the effects of maltreatment on a negative developmental outcome.



Distributions 1 and 3 model lag effects- that is, effects that do not begin with exposure to the risk factor. Research that has examined lag effects often does so in relation to positive developmental outcomes. Questions center on developmental delays experienced by children in high-risk groups. However, if one is focusing on negative outcomes, a lag effect may occur for low-risk groups. For example, maltreated children may experience negative outcomes more frequently and earlier than non-maltreated children. In addition to the timing of the effect, these distributions can be distinguished by the duration of their effect. Distributions 1 and 2 model an enduring effect whereas Distributions 3 and 4 model a transient effect of the risk factor on the developmental outcome. With such flexibility, this approach offers great potential for studying the developmental impact of risk factors.

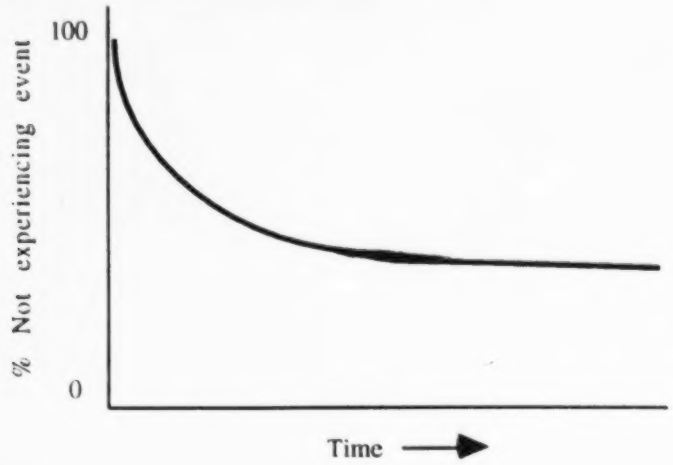
Having established maltreatment as a risk factor for academic difficulties, this approach is ideal to address timing issues. For example, 'When are the periods of highest risk for receiving poor grades and grade repetitions and do they vary for maltreatment subgroups?' and 'Is the level of risk constant or varied across grade levels?' are two issues of interest. For grade repetitions, the periods of highest risk have been found to be grades 1-3 and 7-9, generally (Holmes & Matthews, 1984; Byrne & Yamamoto, 1985). However, there is no comparable research on poor grades. Secondly, while we know that maltreatment, gender, SES, race and mobility are all predictive of academic achievement, it is not clear whether the groups share the same periods of greatest risk or whether the proportion of risk is constant across time. For instance, while research suggests that maltreatment operates as a risk factor for academic difficulties, most studies have averaged across age and grade categories, thus disguising the temporal distribution.

The above questions are important for two reasons. First, there are implications for intervention. It is useful to know what and when children are at risk of some negative outcome so that intervention occurs at the proper time. Secondlly, these questions form the beginnings of a developmental model of maltreatment as a risk factor. Questions about time have fascinated developmentalists throughout history. However, not all have had techniques available to capture time in both its conceptualizations.

Survival Analysis

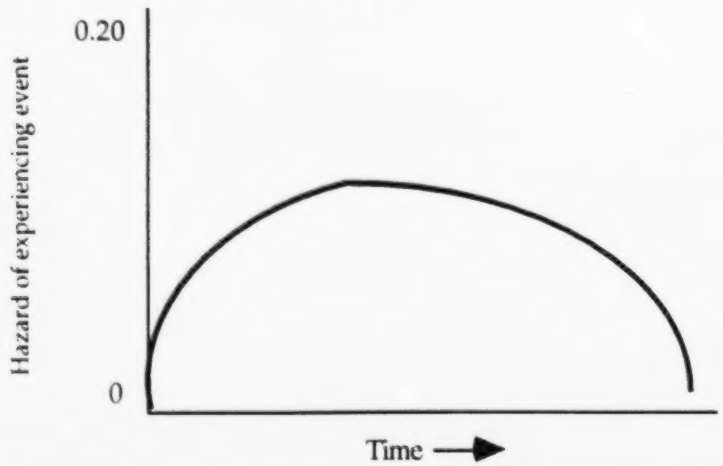
A methodology suited to addressing such questions that has been gaining more exposure in the social sciences has been survival analysis (Singer & Willett, 1991, 1993; Willett & Singer, 1991). In contrast to traditional statistical analyses such as regression and ANOVA which seek to distribute the variance of the dependent variable, survival analysis focuses on the varying conditional probability that an event will occur. Time becomes the dependent variable. The number of subjects who have survived (not had the event occur) at each time is plotted as was hypothetically done in Figure 3.

Figure 3: Hypothetical Survival Function



This is referred to as the survival curve or function. At each time, the probability that an event will occur (given that it has not yet occurred) is calculated: h(t)=Prob[Event occurs between times t and t+1| survival until t]. These calculations are plotted to form what is referred to as a hazard curve or function as in Figure 4.

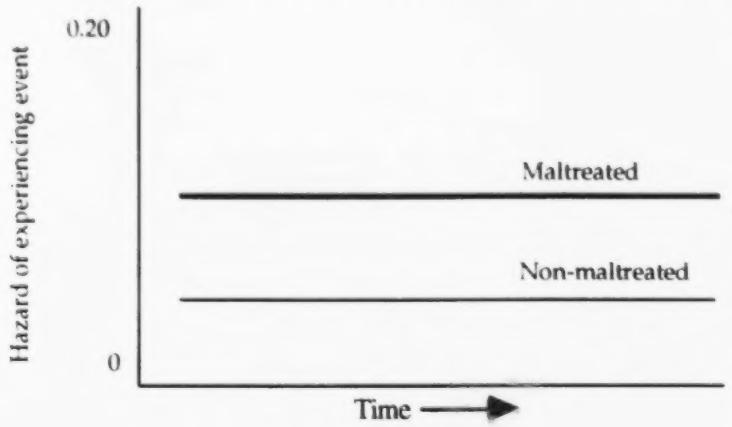
Figure 4: Hypothetical Hazard Function



Both survival and hazard curves can be plotted for the entire population or for individual subgroups (such as maltreated & non-maltreated). This technique allows one to graphically and statistically compare survival and hazard curves for different groups. Graphically, these approaches can assess not only differential risk due to group

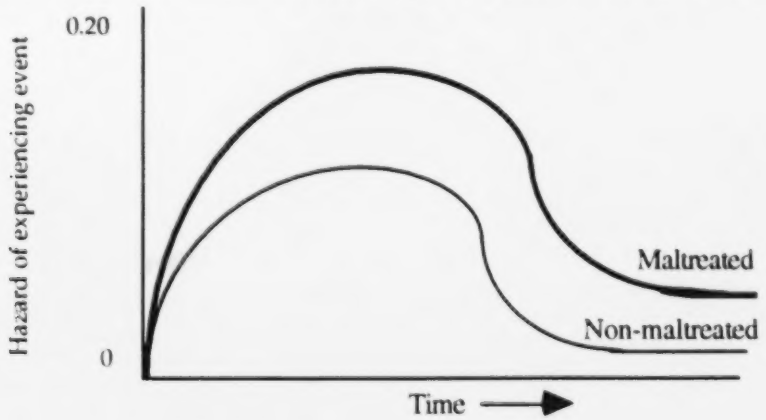
membership but differential timing effects as well. When little information is available about the timing of risk, the default assumption is that the risks for each subgroup are constant and proportional across time. Proportionality refers to the ratio of subgroup risks (i.e. $h(t_i)_{mal}/h(t_i)_{non\text{-}mal}$). If this were the case, the hazard functions for maltreated and non-maltreated children would be expected to be flat as depicted below.

Figure 5: Hypothetical Hazard Functions: Proportional & Constant Hazard



However, if there is research to inform one's predictions, as there is for grade repetitions, one may postulate that curves peak during a specific time as shown below.

Figure 6: Hypothetical Hazard Functions: Proportional & Non-Constant Hazard



This technique treats time as an outcome by examining the amount of time until a negative event occurs. Yet it also treats time as a predictor in trying to model hazard as a

function of time. In doing so, it offers great potential for studying the developmental impact of a risk factor such as maltreatment.

Research questions and hypotheses

For the purposes of this research it was predicted that maltreated children would display a lower survival and thus higher risk for poor grades and grade repetitions as has been suggested by other research. Since no published studies have utilized these techniques to compare maltreated with non-maltreated children with regard to such developmental outcomes, there is no reason to expect the curves for each subgroup to be proportional. Past research has shown that grade repetitions occur more often in the earlier grades (1-3) (Holmes & Matthews, 1984, Byrnes & Yamamoto, 1985) thus this time was expected to be the time of greatest risk for this event for both maltreated and non-maltreated children.

Formulating a hypothesis regarding poor grades was more difficult. Since grade repetitions have been shown to occur more frequently in the grades 1-3 and repetitions are linked to poor grades (Alexander & Entwisle, 1988; Cadigan et al., 1988), one would expect the early grades to be a period of high risk for poor grades. On the other hand, since the material becomes more complex in the higher grades, risk may increase over time. This study was designed to test these hypotheses.

METHOD

A subset of 660 children was taken from the matched sample used in Eckenrode et al. (1993). In this study, all school age children enrolled in public schools in 1987-1988 (n = 8569) in an upstate New York city who had a history of maltreatment were identified through a search of Department of Social Services records. These children were matched with a group of non-maltreated children on gender, school attended, grade level, and neighborhood of residence (cf. Eckenrode, et al., 1993, for details of sampling). The subset of children used in this study was chosen based on the completeness of their

school records. Figure 7 illustrates the 4 categories of children were created according to their censoring status.

Figure 7: 4 illustrations of CENSOR coding

CHILD	K	1	2	3	4	5	6
1	C	C	D	C	B	.	.
2	.	.	B	A	B	C	C
3	C	B	B	.	.	C	B
4	B	B	A	B	A	B	A

GRADE

Child 1 is an uncensored case since it had a complete record until it received a poor grade. Since records are missing early in its career, Child 2 is considered left-censored. All left-censored children were excluded from the sample since no reliable estimates of their duration are available. Child 3 is an example of a child censored due to missing data. Only data that occurred before the missing data were used in these analyses. Finally, Child 4 is an example of a case that is right-censored due to the end of data collection. Grade repetitions, English grades, and math grades (all taken from their school records) were the outcomes of interest. For grade repetitions, duration was the time in school until a grade repetition. If the information of grade repetition was missing but there was information on either English or math grades, a value of 0 (no repetition) was imputed for that time. For English and math grades, duration was the time in school until a D or F or U (unsatisfactory) was received in the subject of interest.

Survival and hazard functions were calculated and plotted for each outcome. The log-rank and Wilcoxon tests were used to evaluate the equality of the curves. While both tests are essentially t-tests, they assign different weights to the time periods. The log-rank test assigns a weight of 1 to all times whereas the Wilcoxon gives greater weight to earlier time periods (SAS Institute).

RESULTS & DISCUSSION

For each outcome of interest, survival and hazard curves were plotted for the entire population as well as maltreated and control groups. As can be seen in Figures 8.1-8.2 , it is estimated that 57% (376/660) of the entire population will not repeat a grade by the end of the sixth grade. The time of highest risk of repeating a grade for the entire population was first grade.

Figure 8.1: Grade Repetition Survival Curve for the Entire Population

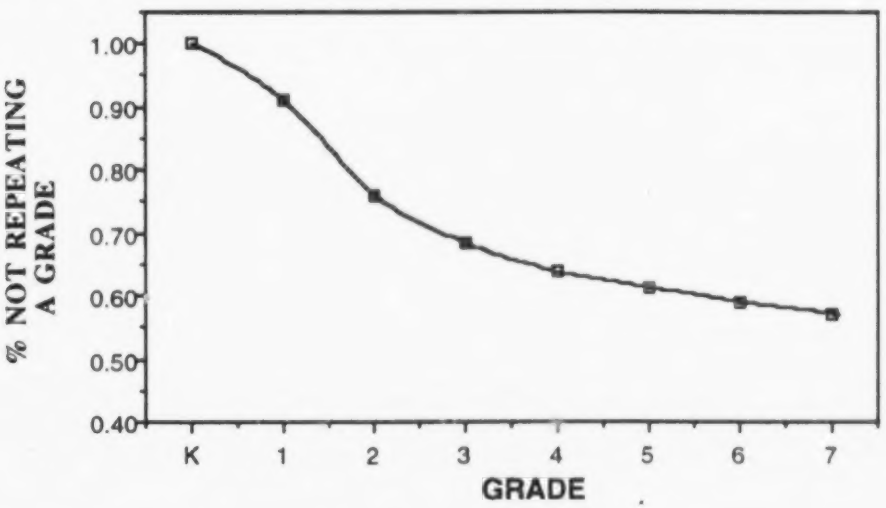
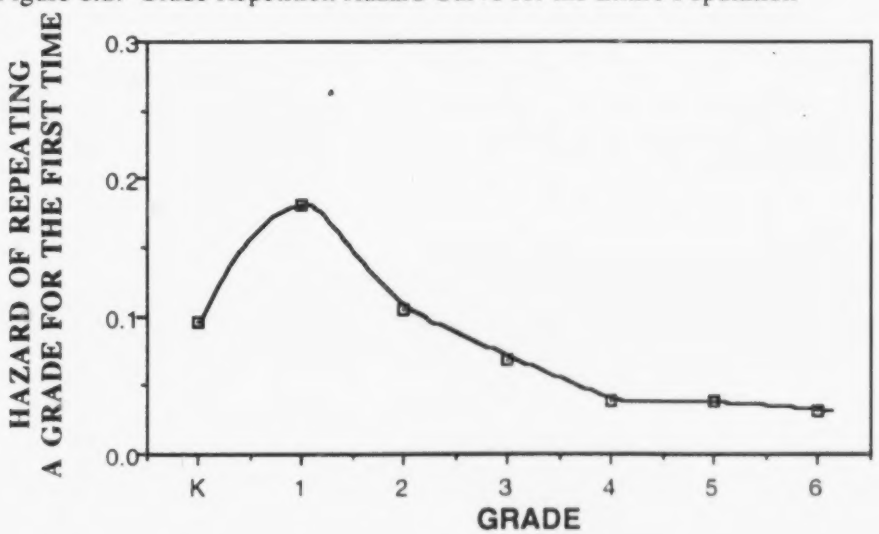


Figure 8.2: Grade Repetition Hazard Curve for the Entire Population



Separating the maltreated from the non-maltreated children, as in Figures 9.1 and 9.2, resulted in striking differences in the survival and hazard functions of the two groups. Sixty-nine percent of the non-maltreated and 45% of the maltreated are expected to complete the sixth grade without a grade repetition.

Figure 9.1: Grade Repetition Survival Curve for Maltreated and Non-Maltreated Groups

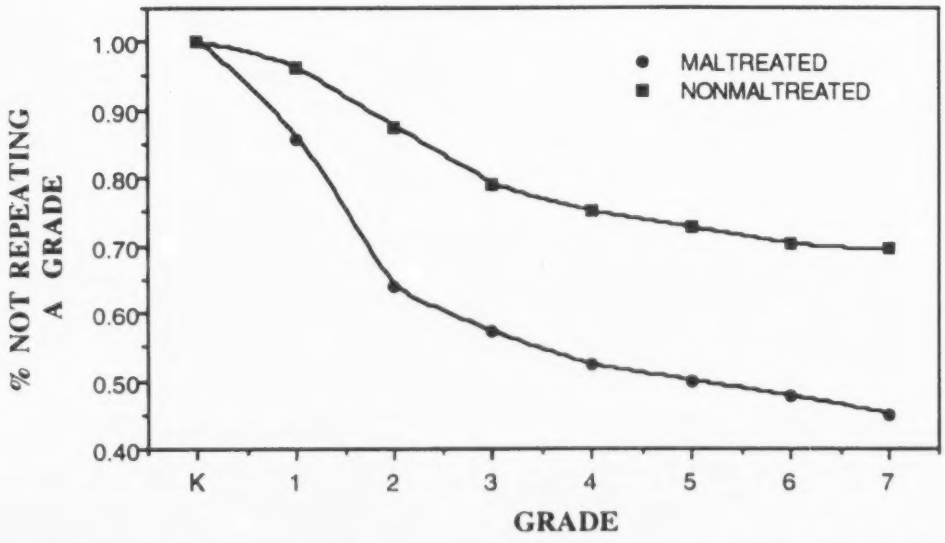
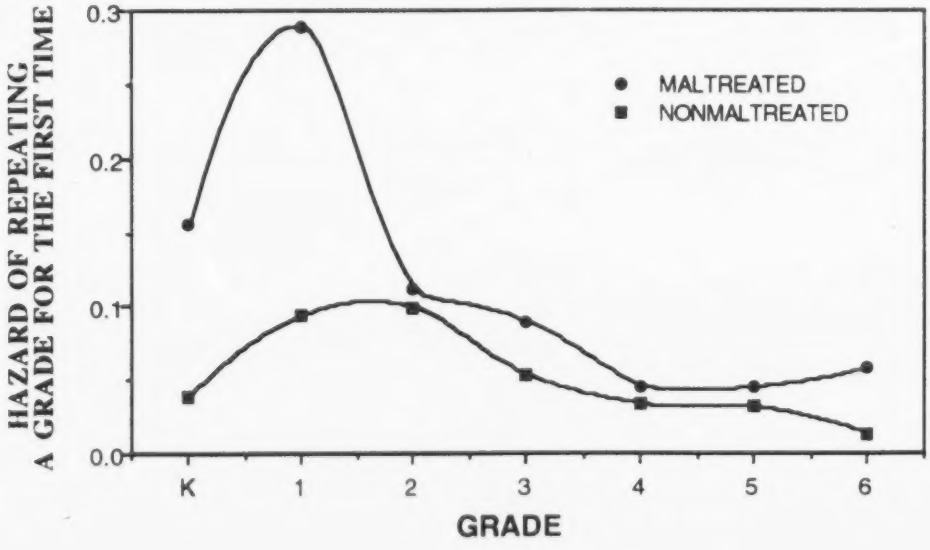


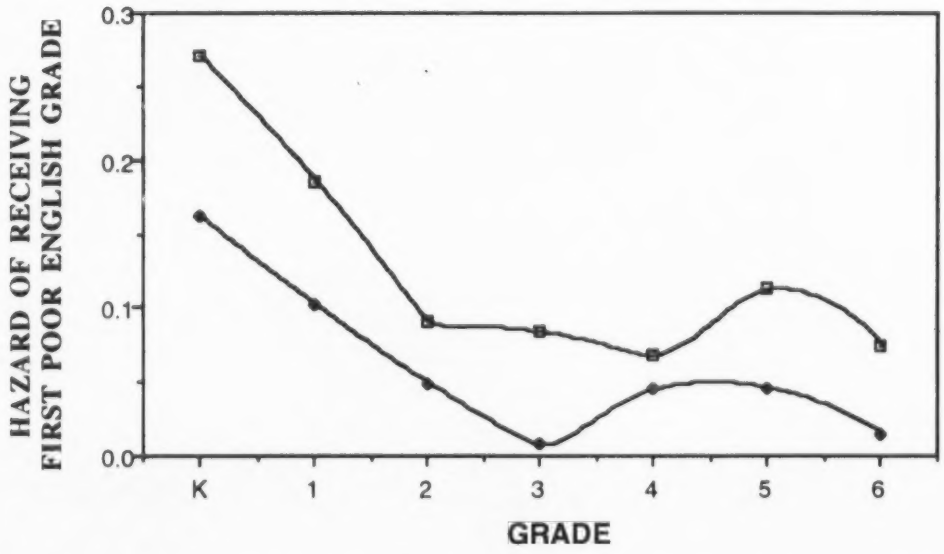
Figure 9.2: Grade Repetition Hazard Curves for Maltreated and Non-Maltreated Groups



Although maltreated children have a greater risk of repeating a grade at all time periods, the time of greatest risk for a grade repetition varies for the two groups. For maltreated children the time of greatest risk is the first grade (hazard=.289) whereas for non-maltreated children it is the second grade (hazard=.0997). The log-rank test has a value of 38.16 and the Wilcoxon test has a value of 42.77 both of which are significant at the 0.0001 level when evaluated against a chi-square distribution with 1 degree of freedom.

Through the sixth grade, it is expected that 54% (326/606) of the entire population will not experience a U (unsatisfactory), D or F in English. Kindergarten and the first grade were the times of highest risk for experiencing this event. Forty-four percent of the maltreated and 66 % of the non-maltreated children are expected to survive through the sixth grade without a poor English grade. Figure 10 displays the hazard functions for maltreated and non-maltreated subgroups.

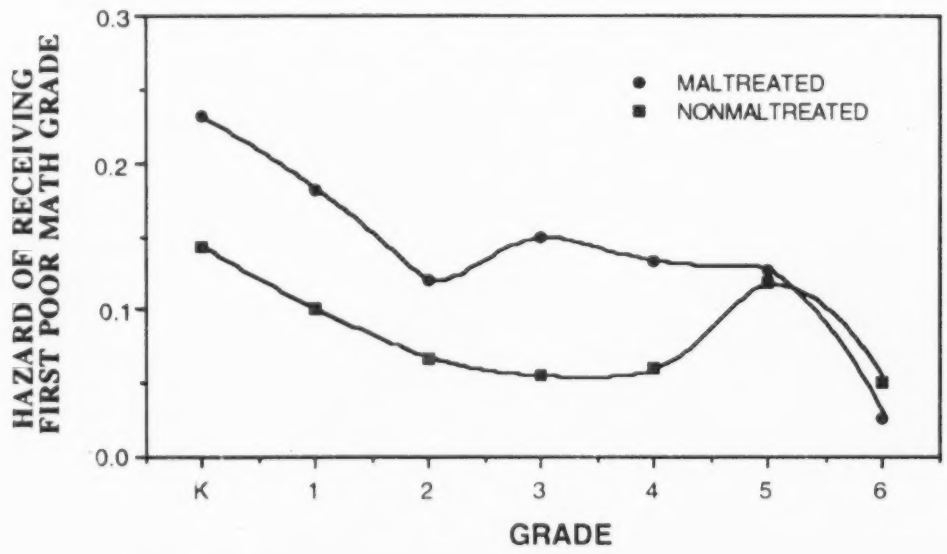
Figure 10: English Grade Hazard Curve for Maltreated and Non-Maltreated Groups



As expected, maltreated children displayed a higher risk for these events across all time periods. Kindergarten and the first grade are the times of highest risk for both maltreated and non-maltreated children. The log-rank statistic has a value of 21.3 and the Wilcoxon test has a value of 15.8 both of which are significant at the 0.0001 level.

Forty-seven percent of all children are not expected to receive a D, F or U (unsatisfactory) in mathematics. Kindergarten and the first grade are the times of greatest risk. Only thirty-eight percent of the maltreated and 55% of the non-maltreated children are expected to survive through the sixth grade without a D, F, or U (unsatisfactory) in mathematics. Maltreated children displayed a higher risk across all time periods except the sixth grade. Figure 11 illustrates that the time periods of highest risk for maltreated children were kindergarten and the first grade whereas for non-maltreated children they were kindergarten and the fifth grade.

Figure 11: Math Grade Hazard Curves for Maltreated and Non-Maltreated Groups



The log-rank statistic has a value of 16.5 and the Wilcoxon test has a value of 14.1 both of which are significant at the 0.0001 level.

While these preliminary results are primarily descriptive, they tell us a great deal more than traditional statistical measures such as means. For instance, while finding that maltreated children are at higher risk of academic difficulties is not surprising, these results suggest that maltreated children's periods of highest risk may depend upon the outcome of interest. Whereas they were similar for English grades, they varied for grade repetitions and math grades. Future research will extend these techniques to school

oriented outcomes such as problem behavior. Also, this research does not address the impact of moderators such as gender and SES. Research in progress will incorporate these covariates into statistical models of the hazard functions of each outcome using discrete survival analysis (Singer & Willett, 1993).

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